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INSTINCT AND THE RATIONAL LIFE

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I

MAN is familiarly known as the rational animal. He is well aware —or can be made aware—that if $a = b$, and $b = c$, then $a = c$. And he is the only animal so far as we know who can follow even that simple process of reasoning. Reason thus becomes a recognition mark by which the genus *Homo* may be distinguished from the rest of animal creation.

Recognition marks, however, do not comprise all the characters of an individual. They may not even suggest those fundamental attributes without a knowledge of which no adequate understanding and appreciation of the individual is possible. Though all men may show signs of rational life, if only scraps and patches of ratiocination conspicuous enough to identify them as human animals, few would venture to believe that human nature is a patchwork of this sort. To confound man with the recognition mark of his rationality is to confound an elephant with its trunk, or a dog with its bark. Just as there is more in the concept *elephant* or *dog* than appears in the signs by which we immediately recognize them, so there is more in the concept *man* than appears in an account, however complete, of his rational life. Man is indeed a rational —*the* rational animal. Reason, however, is but one of his essential attributes. For man is also profoundly a non-rational animal. It is upon the significance of this fact that I would now direct especial attention.

II

It is customary to speak of human attributes as higher and lower, as better and worse; of human acts as noble and despicable, right and wrong. And it is natural that those who, living in a social order, are constantly confronted with problems of conduct, should be prone to measure all personal experiences in terms of a moral standard.

In the present discussion, however, moral values do not immediately concern us. Human impulses have many motives; and the actions which lay them bare are determined now by reasons, now by instincts, or a variety of physiological conditions, none of which may possess any moral significance in themselves. It is difficult, however, to appreciate this latter non-moral aspect of life. And that same difficulty manifests itself in contemplating the forces of inorganic nature as well. Lightning falls upon a den of thieves. To many it is a sign from the hand of God. To others, it is a discharge of electrical energy induced by large differences of electrical potential between the earth and a cloud perhaps a mile above it. While the first interpretation centers attention upon the moral qualities of the hapless wretches who may be destroyed, the second quite neglects that aspect of the situation. The annihilation of the thieves may be socially desirable; but to explain a cause in terms of its effect is to put the proverbial cart before the horse.

Human actions, however, we do not so easily divorce from their consequences. For consequences are likely to be more tangible than causes, more effective in arresting our attention. It is easier, also, to assign causes than to find them. In the midst of a world of problems the mass of mankind devotes very little energy to the serious investigation of them. Yet we are all unsparing critics. We are judges. We think so much in terms of praise and blame. We use the latter on the whole with the more accustomed ease. Yet there can be no more reason for finding good than evil in an action if neither is there.

III

Man is, then, not only a rational animal, many of whose actions possess deep moral significance; he is also a non-rational animal, the real significance of many of whose actions is only obscured by the intrusion of rational or moral standards. It will be helpful, I believe, to consider these non-rational elements as parts of his essential nature like the rest, neither higher nor lower, better nor worse, more nor less of the spiritual essence. Human nature thus becomes, for practical purposes, a complex differing for different individuals, whose essential characteristics can only be learned through the activities which give them concrete expression. I say for practical purposes, because the value of a definition lies in its efficiency as a tool. Facts do not fit themselves to definitions. Definitions must be applicable to the facts. To define man as an animal with an immortal soul would be of little practical help in distinguishing men from dogs. For this would merely develop the need of a practical criterion for an immortal soul applicable to both dogs and men.

Similarly, it would be difficult to suggest any *workable* definition of human nature that did not involve the activities by which it is made objectively visible. This follows from the fact that while we possess a certain intimate and direct consciousness of much of our own personal lives, we can interpret the lives of others only through the medium of their actions. As students of human nature, then, we become, perforce, students of behavior.

The actor, whose chief business it is to give to mimic emotion the semblance of reality, is especially conscious of this fact. For progress in his art depends primarily upon the choice of signs. All signs are not equally full of meaning. Nor is there a direct proportion between intensity of action and emotion. Subtleties of expression are now eagerly sought. New possibilities are boldly investigated. Even the long neglected human back has developed unexpected power to register vicissitudes of human feeling. Speech itself, the most familiar means of communication between persons, is but sign language, owing its popularity to its utility not only for wide range but great niceness of expression.

It is one thing to make a conscious sign, and quite another to receive and interpret it, as we are all sufficiently aware. Often, however, the most significant signs are given unconsciously. In such cases we may at times reveal ourselves unwillingly. At other times, our reactions, did we but note them, would reveal us to ourselves.

IV

The actions which in their totality constitute the behavior of the individual fall roughly into one or the other of four convenient groups, according as they are rational, intelligent, instinctive or reflex.

Rational behavior typically indicates a capacity to form judgments, to appreciate the meaning of *therefore* and *because,* to classify and generalize experience. The invention of a mechanical device, the solution of a problem, the prosecution of an argument, are some of the numerous examples of rational behavior that suggest themselves at once. It is not needful that the device be salable, the solution sound, the argument effective, provided only the process by which the end is reached indicates the capacities of the mind that have already been enumerated. Such indication is not always clear. A chimpanzee, for instance, draws food toward its cage by means of the crooked end of a cane. It uses a tool. If we do not choose to call these animals rational that thus adapt implements to definite ends, we may nevertheless agree that such behavior indicates the possession of mental attributes closely akin to reason in a rudimentary form.

V

Turning now to a consideration of intelligent behavior, we shall find it well exemplified in the dog. This animal does not reason, nor does he appear from the evidence at hand to be able to use tools like the monkey. He is essentially a non-rational animal. Yet he can profit by experience. He can learn. This capacity to learn has been conveniently distinguished from reason under the name of intelligence. The term is used commonly in a looser sense to include reason as well. But the distinction justifies itself when, upon analysis, we find that much of the behavior that is usually classed with rational as intelligent resolves itself into actions that can be accounted for by a merely canine capacity to learn new tricks. So much of life consists in sitting up at command, barking for metaphorical lumps of sugar, learning to heel, and wearing a muzzle without protest.

Intelligent animals are distinctively characterized by the possession of associative memory. They are able not only to remember, but to associate different experiences in their memory. The essential part of the learning process is, therefore, the establishment in the memory of an appropriate association. That is what one must accomplish in training a dog. But one soon finds, when he engages in such a task, that he must also gain the animal's attention and direct it to the desired end. So he rewards success, or rebukes failure, until the animal shows by the precision of its response that the association between the latter and the signal of command has become definitely established. The process is the same, whatever the object; whether the dog is destined for domestic service or for the stage.

It would be interesting to digress here into a consideration of the value of punishment as a pedagogical device for enforcing attention. If there is any justification of the old-fashioned spanking, it is to be found, to my mind, in such a function.

A more immediate problem, however, lies in the query whether, after all, the dog in learning to obey his master's command, did not employ in some degree the process of reasoning. Did he know why he was rewarded or why punished, and act accordingly? If so, the evidence from this and many such experiments fails to indicate the fact; while the following investigation of the association processes in the dog demonstrates the formation of typical associations in the complete absence of rational processes.

It is well known that under certain circumstances the mouth waters, which is only a familiar way of saying that the flow of saliva into the mouth has been increased. The sight of food—even the thought of some appetizing dish—and a number of other causes may produce this result, which is in every case due to the stimulation of the salivary glands. Among the effective stimuli, one of the most convenient for experimental purposes, is hydrochloric acid, a few drops of which, under the tongue, produces a definite increase in the secretion of the parotid gland—which may be remembered as the seat of trouble when one suffers from *mumps.*

Now it is possible, by a slight operation, to divert the flow of saliva from the parotid gland away from the mouth to the exterior, so that the rate and character of the flow may be accurately observed. A method is thus obtained not only for estimating the effect of various stimulating substances upon the salivary glands, but, which is far more significant, for measuring in concrete physiological terms the processes that take place in the higher centers of the brain. Suppose, now, that as a few drops of hydrochloric acid are placed under the tongue, a whistle of a given pitch is blown. Suppose, further, that this simultaneous application of acid and sound is repeated as many, let us say, as twenty times. Then suppose that at the next trial, the acid is abandoned, but the whistle is sounded as usual. Repeated experiments have shown that under such conditions the sound of the whistle, which at first produced no appreciable effect upon the salivary glands, now distinctly accelerates the flow of saliva. That this is an example of the establishment of a new association without the aid of reason follows from the fact that the mouth waters without consideration, as a result of reflex stimulation of the salivary glands which the animal concerned may even quite fail to notice.

The mechanical preciseness of this association is especially emphasized by the fact that it obtains only for whistles of the same pitch. Even the most trifling differences in this respect reflect themselves in the rate of the salivary flow. The association involves a particular tone, not sound in general. It is an association of a very definite, circumscribed type. It exhibits nothing of that adaptability which makes the behavior of tool-using animals so noteworthy.

Yet it is just this type of cerebration that is involved in a vast number of our everyday actions. We even make a boast of it. This man has voted with one political party so long that his dogged loyalty has become his political virtue. That man believes that the duelling code to which he has been brought up is a necessary part of the library of every gentleman. We may have learned to like figs and olives, but we still eschew horse flesh. We are assured that many of the processes by which foods are prepared for the market are irrational, but we continue to demand them. We estimate our guests by their table manners. And we give our favor to a soft falsehood, snubbing a harsh truth. We prescribe not only the canons of dress, but of esthetic taste. We know what we like—alas. We set the limits of polite conversation. We even dictate terms of thought itself. We persecute the genius who would enlighten our ignorance, because his ways are strange. We applaud the demagogue for speaking the fluent language of our own mediocrity. And we marvel at our intelligence.

The same facts confront us in the very institutions whose sole reason for existence is the instruction of the young. The earlier years of our school life are devoted largely to the training of the senses and muscular coordinations, and to the formation of new associations in language and number. Later, the persistent argument for mathematics —that it trains especially the rational powers of the mind—only accentuates the fact that in the secondary schools also a large place in the curriculum is given to studies that do not make such an appeal. The helplessness of many a college entrant when thrown upon his own resources points to the same conclusion. We may be rational animals, but a large proportion of our formal education consists in learning, like the dog, to do new tricks.

Whatever the reasons for the prevalence of this cookbook type of instruction throughout the school system, the fact shows how conspicuously our educational methods reflect what the illustrations previously given may have made clear, namely, the important function of associative memory in the life of man. And an examination of associative memory leads us, as we have already seen, to a type of physiological mechanism that has now been partially investigated by seizing the opportunity for analysis afforded by the salivary reflexes of the dog.

VI

Those actions may now be briefly considered which are called instinctive. It will not be possible to discuss the various definitions that have been offered from time to time for the word instinct. Some are concerned with psychical attributes, some with physiological responses. Some involve genetic ideas like the phrase *inherited habits,* while others lay stress upon the adaptive value of instinctive acts in the life of the organisms that exhibit them. So many definitions have been proposed and so many criticisms of the proposals have been made, that several authors have advocated the abandonment of the term altogether, as lacking sufficient precision for satisfactory discussion. I shall not follow this radical procedure, however, for there is a definition of instinct that is not only simple but will, I feel sure, be serviceable in the present discussion. According to this definition, instincts may be regarded as complex reflexes. This is diametrically opposed to the view, still popularly current, that instincts are superhuman endowments, by means of which various animals are able to foretell events. Such feats are feats of magic. And whatever instinct may be it is not magic. On the contrary, the conception that instincts are merely complex reflexes has a sound basis in our experience, as the following illustration will show.

Let us consider, then, the feeding instinct of the common freshwater crayfish. The body of this lobster-like animal is composed of a series of segments, each furnished with a pair of appendages. The appendages are all constructed on the same general plan, but variously fashioned in accordance with different functions in different parts of the body. It will be necessary to consider now only the highly modified mouth parts and the walking appendages, the foremost three pairs of which bear pincers at their tips. Suppose a bit of meat is placed near one of the third pair of walking appendages. It will not be long before that appendage moves toward the morsel, grasps it in its pincers and carries it forward toward the appendage immediately in front. This second appendage, almost identical with the last in structure, moves backward and receives the morsel, then carries it forward to the mouth. The meat is there seized by the prehensile maxillipeds, carried inward and finally engulfed. In these coordinated movements of the successive appendages, the movements of the one appear to initiate and control to some extent the movements of the next in the series. This is due to that fact that the appendages communicate with each other through the nervous system. The central nervous system of the crayfish is composed of a chain of masses of nerve cells extending from one end of the body to the other, a pair of such ganglionic masses sending nerves to each pair of appendages. By cutting the nerve cords connecting the successive ganglia it is possible to destroy the coordination that previously existed between the appendages to which the nerves from these ganglia are distributed. By severing the nerve chain between every two ganglia it is possible to divide the organism into a series of non-coordinated parts. The appendages of each segment react normally to stimuli, but such stimulation no longer induces reaction in the appendages of a neighboring segment. Each segment with its appendages is thus seen to be a complete reflex mechanism of nerve and muscle elements. The difference between the reflex movements of the appendages of any given segment, and the coordinated movements of the appendages of several segments which are characteristic of the normal feeding reaction of the animal is one illustration of the difference between a relatively simple reflex and an instinctive action.

The definition of instinct thus illustrated has been formulated because of its objective value. It includes no mention of the possible cognitive and emotional accompaniments of instinctive action. For, while psychic facts of this sort can be shown by direct testimony to accompany instinctive acts in man, it is quite impossible to obtain such testimony from the lower animals, in which instincts exist in their purest and simplest forms, and are most amenable to physiological analysis. And it is the latter with which we are especially concerned.

VII

It will be desirable now to indicate somewhat more fully the characteristics of reflex actions. The term *reflex* was first introduced to characterize the response of a motor element in an organism to a stimulus applied to a sensory surface that is connected with the motor element by nerves through a nerve center—such as the spinal cord of a vertebrate or a ganglion in the nerve chain of the crayfish. For the propagation of the nerve impulse from the sensory surface to the nerve center, and from the nerve center to the motor element strongly suggests the behavior of a beam of light that falls upon and is thrown back from a reflecting surface.

Since the knowledge of reflex actions was developed originally upon organisms possessing a nervous system, it is natural that reflex action should still be associated by many with a neuro-muscular mechanism. Actions which differ in no essential particular from those characteristic of a neuro-muscular mechanism, occur, however, in such organisms as the sensitive plant, *Mimosa*, and the simplest animalculæ, none of which possesses either nerves or muscles. They occur also in many of the tissues of our own bodies which respond to stimulation of various sorts without the intervention of either nerves or muscles. One such case will sufficiently illustrate the fact. The pancreas—one of the sweet breads of commerce, and the most important single digestive gland—pours its juices into the small intestine only when a chemical substance known as secretin is brought to it by the blood stream. The secretin itself is produced in the cells of the intestinal wall under the influence of the acid which comes into the intestine with the partially digested food from the stomach. Careful experiments have shown that in the production of secretin by the intestinal walls, and of pancreatic juice by the pancreas, nerves play no part. Chemical substances acting directly on glandular tissues set up in the latter energy transformations that result in the production of the secretions characteristic of the glands in question.

The activities of many parts of the body are similarly brought into correlation by means of chemical substances or *hormones* that are carried about by the blood. Correlations of this sort exist between the ovaries and the uterine changes connected with menstruation, between the testes and secondary sexual characters of the male, between the increased production in the blood of carbon dioxide that is a normal product of physical activity, and the more rapid and labored breathing that follows pronounced physical exertion.

Further citations of this sort of reflex are unnecessary for our purpose. The cells of which the various tissues of the body are composed are all irritable, since they react to appropriate stimulation. As they all arise in development from a common source, the fertilized egg cell, the specific character of the reaction of a given cell is determined by the direction in which the cell has differentiated. A white blood corpuscle, possessing neither nerves nor muscles, itself but a single cell, receives and conducts stimuli, contracts, secretes chemical substances—exhibits, in fact, in some degree, all the properties that appear in such specialized tissues as muscle, nerve, gland, where contractility, or conductivity, or secretability, as the case may be, has been augmented out of all proportion to the others.

The more the nature of reflex action is investigatetd, the more clear is it that nerves and muscles, though conspicuous in certain of its types, are in no sense necessary to the fundamental physiological activities that lie at the bases of the actions themselves. If this is clear, then it will be possible to suggest the important similarity to reflex action of such a well known phenomenon in the organic world as the explosive response of gunpowder to the touch of a lighted match. Reflex actions are due essentially to transformations of energy that are initiated by some sort of stimulus; and the energy changes that occur in the protoplasm of which living bodies are composed have been shown by many careful researches from the time of Lavoisier to the present to follow the laws that are familiar to the physicist and chemist.

This connection between physiological processes and chemical reactions is of especial significance for students of animal behavior; for just as chemical reactions are controlled by conditions, so the constancy of reflex and instinctive actions depends upon the constancy of physiological processes and conditions by which they are controlled. The reactions that constitute the behavior of an organism vary in this regard. Some are more stable than others, retaining a relative constancy amid fluctuating circumstances. Which are they, rational or instinctive? Reflex or intelligent? It is important that we know and know why.

VIII

In discussing the problem that thus presents itself, it will be convenient to distinguish between those conditions of stability which are in the main structural and those which are in the main functional. It is needless to dwell upon such obvious correlations as the flying and pecking instincts of birds with the structure of wing and bill, and the entire absence of such instincts among goats and monkeys; upon the connection between the breathing organs of the salmon and an exclusively aquatic life, or between the traditional sluggish movements of the snail and the peculiarities of its locomotor mechanism. Large numbers of similar instances of the limitations imposed by structure upon behavior present themselves at once. Similarly, any simple reflex that depends on the connection of sensory with motor elements by means of nerves that pass from one to the other through a nerve center, fails when at any point the necessary connections are broken. While the latter exist unimpaired, a certain stability of reaction is maintained.

Less obvious, but more intimately significant is the relation between the structure of the central nervous system and the behavior of vertebrated animals. In its simplest form, the central nervous system of vertebrates is constructed on a segmental plan, suggesting in a general way the segmental distribution of nerve centers that has already been noted in the crayfish. Among the lower vertebrates this is especially evident. In fact, the removal of the entire brain from a frog does not interfere in the slightest degree with the complicated responses of the limbs to stimulation of a sensory surface that are characteristic of the normal creature. A drop of acid placed on its back calls forth the most accurately coordinated movements of the hind limbs directed toward the removal of the irritation; movements whose definite adaptation to that end presents a purposive aspect that is customarily associated only with conscious motive.

Even small pieces of the spinal cord suffice for similar reflexes. The embrace of the female by the male during the breeding season is due to a convulsive reflex of the arms brought about by stimulation of the skin below and between them. Not only does this reflex persist after decapitation, but even after the removal of all the body except a narrow segment made by cross cuts immediately in front of and behind the shoulders. By irritating the skin on the lower surface of this body ring, the arms can be made to perform the clasping movements characteristic of the normal frog.

In the higher vertebrates, experiments do not reveal so clearly the segmental character of the nervous system. Cats have been known to live years with severed spinal cords, but the reflexes of the limbs, thus isolated from any influence of the brain, are neither so definite nor so well adapted to useful ends as in the frog. This statement applies with still more force to the monkey; while in man, when the spinal cord is completely severed and the connection between brain and limbs thus interrupted, muscles waste away, skin reflexes quickly disappear, and even the well known knee jerk soon is lost. The parts that in the frog are to some extent isolable and autonomous nerve centers, in man have lost their autonomy and function only as parts of a larger whole.

These facts are definitely connected with the finer structure of the nervous system. In the nerve cord of vertebrates are tracts of short nerve fibers that run between segments of the same region, and tracts of longer fibers that run between segments of different regions, and between the cord and the brain. If the longer fibers account for the integrated activity of the parts which is so conspicuous in man, man should possess them in relative abundance. Man does, indeed, possess them in relatively greater abundance than any other animal. With the increased development of these longer association fibers, the higher nerve centers appear to have taken over the control of functions previously exercised by the segments of the spinal cord. Thus a new position of stability is reached through new complexity of the nervous system.

These illustrations must suffice for the present to indicate the relation between the typical behavior of organisms and their structure. Let us turn now to types of behavior that depend essentially on the stability of physiological conditions.

The respiratory mechanism, by means of which we breathe, is composed of numerous muscles acting upon skeletal elements and stimulated through nerves from the controlling nerve center in the base of the brain. If this mechanism were not automatic we should die. Yet the activity of the respiratory center on which this automaticity depends is not possible when the quantity of carbon dioxide which as a normal product of the decomposition of the tissues, is always present in the blood, falls below a certain minimum. Similarly, the necessary tone of the heart and blood vessels is controlled by the secretion that is poured into the blood from the adrenal glands. The control of the digestive function of the pancreas by the *secretin* formed in the walls of the small intestine has already been described.

From such stable, hereditary reflex mechanisms, whether simple or complex, that have been established independently of experience, Pavlov has distinguished as *conditioned* reflexes, those which, like the salivary reflex of the dog, are products of training. They are based, it is true, upon an hereditary associative mechanism, or, as we are wont to say, an hereditary tendency or capacity, but their establishment as definite associations is only accomplished through individual experience. These associations are on the whole formed readily and readily destroyed, as experiments have shown. They are accordingly less stable than the reflexes of the *unconditioned,* instinctive type. Yet out of such conditioned reflexes is constructed, as has already been indicated, the physiological mechanism of intelligent behavior.

IX

It has been indicated that the stable hereditary mechanisms which exist in bewildering variety in the human body must operate under the conditions which the environment imposes. These may be permanent, dependent, like the body temperature, upon a stable, hereditary heat regulating mechanism. Or, like changes in temperature, doses of disease toxins, alcohol or strychnine, they may be temporary, the functions disturbed ultimately resuming their normal course. The fact that reflex and instinctive actions are subject to change under changed conditions has led authors frequently to speak of instincts as modifiable. That this expression may not be misleading, it should be remembered that reflex and instinctive actions, like physical and chemical reactions, are resultants of a play of forces. And since instinct is but a name that is conveniently applied to certain complex types of reflex action, it can only be said to be modifiable, as a physical or chemical reaction is modifiable, that is, through some change in the complex of conditions of which it is a product.

Modifications of instinctive action by changing the conditions, it is easy experimentally to induce. It will be well to select for the purpose as simple an organism as possible. Certain minute inhabitants of many a wayside pool, organisms that are commonly known as water fleas, will admirably serve. Gathered into a dish and placed before a window, many of them pay no apparent heed to the light. On the addition of a modicum of carbonated water, however, they turn with almost military precision and swim rapidly toward it. Remove the carbonic acid; they scatter. Replace it; again they congregate next the window. There is an obvious connection here between the presence of carbonic acid and the reaction of the organism to light.

The caterpillar of the moth *Porthesia* affords another case in point. In the spring it awakens, hungry, on the twig to which it has clung through its long winter sleep. Almost the first thing it does is to climb upward. In so doing, it discovers the swelling succulent bud at the end of the twig, and feeds forthwith. Having feasted, it wanders away, later to ascend another twig, perhaps, to another feast.

Nothing, at first sight, appears more purposeful than such behavior, more the result of conscious design. Yet no appearance could be more deceptive. If the position of the twig is reversed, the caterpillar crawls upward just the same. It crawls upward away from food quite as readily as it crawls toward it, even though in so doing it follows the path to certain starvation. The facts are that when underfed, it responds to the pull of gravity by crawling away from the center of the earth, and that feeding tends to destroy this reaction. And a sound interpretation of these facts is, that the substances diffusing into the body through the walls of the digestive tract modify the response of the instinctive mechanism that determines its reaction to gravity, just as—though in an opposite sense—the carbonic acid diffusing into the body of the water fleas affects their reaction toward light.

These examples must suffice to illustrate the effects of transient conditions on the relatively stable mechanisms of instinctive action. Reflexes of the conditioned type are similarly subject to control. One of the most characteristic effects of alcohol on the human organism is its depressing action. In sufficient quantities it induces forgetfulness. It weakens the power of repression. It dims the mental vision we call foresight. Under its influence men frequently talk much and loudly when silence were wiser; they lose their sense of fitness and proportion. All of these effects are due to its action as a physiological depressant or inhibitor. And the physiological mechanism depressed or inhibited in each case is a conditioned reflex, a mechanism of association, a product of individual experience.

Strychnine, on the other hand, is a stimulant. In moderate doses, it so affects conditioned reflexes as to quicken memory, clear the mental vision, enliven thought, facilitate the establishment of new associations.

Along with their influence over reflexes, whether conditioned or unconditioned—and they exert control over both—these drugs produce marked effects upon the emotional and temperamental traits that belong to what is called the *disposition* of man. In this respect, they are but two of many chemical substances whose presence in the blood stream is known to be associated with predictable emotional states. Many of these, like the secretions of the thyroid and adrenal glands, are formed in the body itself. Though it is not possible to dwell further on these facts at this time, their significance for any physiological analysis and control of psychic states cannot be over-emphasized.

X

Reflexes, whether of the unconditioned, instinctive, or of the conditioned, associational type, are controlled not only by chemical environment. They are controlled by each other as well. When two instinctive mechanisms are simultaneously stimulated, the activity of the one may *inhibit* the other, as the reaction of the water fleas previously considered to a touch has often been observed to inhibit their response to light; or, one may *augment* the other, as the reaction of a frog's hind leg to a given mechanical stimulus is augmented when a shrill whistle is blown at the moment the mechanical stimulus is applied.

Such examples are closely paralleled in the experiments of Pavlov on the salivary reflex of the dog. For not only has it been found that the slightest unusual sound may diminish the salivary flow, but that the sight of a person with whom the dog is on unfriendly terms may increase it.

XI

If the facts that have been thus far presented show that the human capacity to learn is on its physiological side a capacity to form reflexes of the conditioned type; that the associative memory can be controlled by controlling the reflex mechanism which is its physiological counterpart; it remains to consider whether the rational life of man can be connected helpfully with similar conceptions.

The difficulty of distinguishing sharply between rational and intelligent behavior has already been indicated. Among genetic psychologists, it is commonly agreed that the capacity to use tools—as represented in the chimpanzee—is a further evolution of the capacity to learn that is characteristic of the dog. And though few may be ready to grant that those animals which are capable of using tools are thereby typically rational, few are disposed to deny that such a capacity touches the threshold of reason. Reason thus appears to be but a further extension of the power of association. Whereas, in the dog, associations are formed only between objects or events related in time or space, in the ape, the adaptation of an implement to a use involves far more complicated processes of association, and marks a long step toward the recognition of relations of cause and effect. Whether the further step to behavior of an undoubtedly rational type is longer or not must remain for the present largely a matter of personal judgment. The pertinent anatomical and physiological facts that are available minimize the difference. The cortex of the cerebral hemispheres is necessary to both intelligent and rational action. Minute and careful examinations of its structure have failed as yet to reveal any indication of separate mechanisms for the two. The influence of drugs on rational behavior is essentially what we have seen it to be on intelligent behavior. Alcohol confuses many a clever head; laughing gas, according to William James, makes folly seem like the quintessence of sense; and strychnine sharpens the wit as well as accelerates the learning process. Finally, that reasons, like conditioned reflexes, now appear to hinder, now support each other, are facts so poignant in our every-day experience as to demand no illustration.

If, then, one is justified in believing that the rational behavior of man is dependent on associational processes, rooted in and determined by physiological reflexes, man's conduct becomes interpretable in terms of those reflexes. Certain relatively stable hereditary complexes of these, existing as instincts under a great variety of forms, give character to conduct, and the essential flavor to personality. Certain other complexes, less stable, fashioned out of individual experience and rearranging their elements far more readily in response to changing circumstances, while they provide the individual with an invaluable mechanism of adaptation, define him less conclusively to his fellows. As a rational animal, man possesses an invaluable hereditary mechanism for forming associations of the most complex and general type. Through the possession of this mechanism he has become the lord of all creation. But just as it has been the essential source of his power, so it has provided him with opportunity for the most stupendous follies. As a rational animal, man is both wise and foolish.

But even as a rational animal, wise or foolish, his conduct, so far as it is subject to scientific analysis, appears to be controlled by nonrational physiological mechanisms that respond to stimulation in accordance with physiological laws. As John Dewey says,

> It is not we who think, in any actively responsible sense; thinking is rather something that happens in us.